28. A single crystal gallium nitride substrate according to Claim 27, wherein a direction of a shortest repetition pitch which is equal to a shorter side of the equivalent rectangles or a shorter orthogonal line of the lozenge of the two-fold rotation symmetry pattern is either a <1-100> direction or a <11-20> direction.

29. A single crystal gallium nitride substrate according to Claim 22, wherein a shortest repetition pitch of the closed defect accumulating regions (H) ranges from 50 μ m to 2000 μ m on the surface regularly and periodically provided with the fundamental units (Q).

30. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating regions (H) extend in a c-axis direction and penetrate the substrate crystal.

CLAIMS 31-72 CANCELLED

1. A single crystal gallium nitride substrate having a top surface and a bottom surface, comprising:

a closed defect accumulating region (H) including a core (S) penetrating the substrate and containing many accumulated defects and a grain boundary (K) enclosing the core (S);

an accompanying low dislocation single crystal region (Z) surrounding the closed defect accumulating region (H) and being a single crystal of a basic orientation with low dislocation density; and

an extra low dislocation single crystal regions (Y) lying outside of the accompanying low dislocation single crystal region (Z) and being a single crystal with the same basic orientation as the accompanying low dislocation single crystal regions (Z).

2. A single crystal gallium nitride substrate having a top surface and a bottom surface, comprising a plurality of fundamental units (Q),

the fundamental unit (Q) containing;

a closed defect accumulating region (H) including a core (S) penetrating the substrate and containing many accumulated defects and a grain boundary (K) enclosing the core (S),

an accompanying low dislocation single crystal region (Z) surrounding the closed defect accumulating region (H) and being a single crystal of a basic orientation with low dislocation density, and

an extra low dislocation single crystal regions (Y) lying outside of the accompanying low dislocation single crystal region (Z) and being a single crystal with the same basic orientation as the accompanying low dislocation single crystal regions (Z).

3. A single crystal gallium nitride substrate according to Claim 2, wherein the closed

defect accumulating region (H) is a polycrystal and the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y) build a common single crystal of the basic orientation.

4. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) consists of more than one crystal grain with an orientation which is different from the basic orientation of the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

5. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) consists of more than one crystal grain with an orientation which is common only in a <0001> direction with the basic orientation of the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

6. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) is a single crystal with an orientation which has a <0001> direction reverse to a <0001> direction of the basic orientation of the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

7. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) consists of more than one crystal grain with an orientation which has a <0001> direction reverse to a <0001> direction of the basic orientation of the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

8. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) consists of more than one crystal grain having an orientation slightly slanting to the basic orientation of the surrounding accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

9. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) is a single crystal having the basic orientation or more than one crystal grain being shielded by planar defects or linear defect assemblies from the surrounding accompanying low dislocation single crystal region (Z) and the closed defect accumulating region (H) includes crystal defects.

10. A single crystal gallium nitride substrate according to Claim 2, wherein the defects included in the closed defect accumulating region (H) are linear defects or planar defects.

11. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating regions (H) have a diameter ranging from 1 μ m to 200 μ m and discretely disperse on the surfaces.

12. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating regions (H) have a diameter ranging from 5 μ m to 70 μ m and discretely disperse on the surfaces.

13. A single crystal gallium nitride substrate according to Claim 2, wherein shapes of the closed defect accumulating regions (H) are amorphous, circular or polygonal.

14. A single crystal gallium nitride substrate according to Claim 2, wherein the dislocation density is less than $3 \times 10^7 cm^{-2}$ at spots distanced by 30 μ m from the closed defect accumulating region (H) within the accompanying low dislocation single crystal region (Z).

15. A single crystal gallium nitride substrate according to Claim 2, wherein an average of dislocation density in the accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) is less than $5 \times 10^6 cm^{-2}$ and the dislocation density decreases in proportion to a distance from the closed defect accumulating region (H).

16. A single crystal gallium nitride substrate according to Claim 2, wherein the top surface is a (0001) plane.

17. A single crystal gallium nitride substrate according to Claim 2, wherein top surfaces

except the closed defect accumulating regions (H) are (0001) planes and top surfaces of the closed defect accumulating regions (H) are (000-1) planes.

18. A single crystal gallium nitride substrate according to Claim 2, wherein top surfaces except the closed defect accumulating regions (H) are GaN (0001) Ga planes and top surfaces of the closed defect accumulating regions (H) are GaN (000-1) N planes.

19. A single crystal gallium nitride substrate according to Claim 2, wherein top surfaces of the closed defect accumulating regions (H) are slightly lower than top surfaces except the closed defect accumulating regions (H).

20. A single crystal gallium nitride substrate according to Claim 2, wherein almost all the dislocations extend in parallel to a C-plane in the accompanying low dislocation single crystal regions (Z).

21. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating regions (H) extend in a c-axis direction.

22. A single crystal gallium nitride substrate according to Claim 2, wherein the fundamental units (Q) which contain a center closed defect accumulating region (H), an accompanying low dislocation single crystal region (Z) surrounding the closed defect accumulating region (H) and an extra low dislocation single crystal region (Y) enclosing the accompanying low dislocation single crystal region (Z) are aligned periodically and regularly in a symmetric pattern formed in the substrate.

23. A single crystal gallium nitride substrate according to Claim 22, wherein the symmetric pattern is a six-fold rotation symmetry pattern which aligns equivalent equilateral triangles in two dimensionally closest packed hexagonal symmetry and the fundamental units (Q) are disposed at corner points of the equilateral triangles of the pattern.

24. A single crystal gallium nitride substrate according to Claim 23, wherein a direction of a shortest repetition pitch which is equal to a side of the equivalent equilateral triangles of the hexagonal pattern is either a <1-100> direction or a <11-20> direction.

25. A single crystal gallium nitride substrate according to Claim 22, wherein the symmetric pattern is a four-fold rotation symmetry pattern which aligns equivalent squares crosswise and lengthwise in series and the fundamental units (Q) are disposed at corner points of the squares of the pattern.

26. A single crystal gallium nitride substrate according to Claim 25, wherein a <1-100> direction is either a direction of a shortest repetition pitch which is equal to a side of the equivalent squares of the four-fold rotation summery pattern or a direction of a longest repetition pitch which is equal to an orthogonal line of the equivalent squares of the four-fold rotation summery pattern.

27. A single crystal gallium nitride substrate according to Claim 22, wherein the symmetric pattern is a two-fold rotation symmetry pattern which aligns equivalent rectangles or lozenges crosswise and lengthwise in series and the fundamental units (Q) are disposed at corner points of the rectangles or the lozenges of the pattern.

What we claim is,

1. A single crystal gallium nitride substrate having a top surface and a bottom surface, comprising:

a closed defect accumulating region (H) including a core (S) penetrating the substrate and containing many accumulated defects and a grain boundary (K) enclosing the core (S);

an accompanying low dislocation single crystal region (Z) surrounding the closed defect accumulating region (H) and being a single crystal of a basic orientation with low dislocation density; and

an extra low dislocation single crystal regions (Y) lying outside of the accompanying low dislocation single crystal region (Z) and being a single crystal with the same basic orientation as the accompanying low dislocation single crystal regions (Z).

2. A single crystal gallium nitride substrate having a top surface and a bottom surface, comprising a plurality of fundamental units (Q),

the fundamental unit (Q) containing;

a closed defect accumulating region (H) including a core (S) penetrating the substrate and containing many accumulated defects and a grain boundary (K) enclosing the core (S),

an accompanying low dislocation single crystal region (Z) surrounding the closed defect accumulating region (H) and being a single crystal of a basic orientation with low dislocation density, and

an extra low dislocation single crystal regions (Y) lying outside of the accompanying low dislocation single crystal region (Z) and being a single crystal with the same basic orientation as the accompanying low dislocation single crystal regions (Z).

3. A single crystal gallium nitride substrate according to Claim 2, wherein the closed

defect accumulating region (H) is a polycrystal and the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y) build a common single crystal of the basic orientation.

4. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) consists of more than one crystal grain with an orientation which is different from the basic orientation of the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

5. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) consists of more than one crystal grain with an orientation which is common only in a <0001> direction with the basic orientation of the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

6. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) is a single crystal with an orientation which has a <0001> direction reverse to a <0001> direction of the basic orientation of the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

7. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) consists of more than one crystal grain with an orientation which has a <0001> direction reverse to a <0001> direction of the basic orientation of the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

8. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) consists of more than one crystal grain having an orientation slightly slanting to the basic orientation of the surrounding accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

9. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) is a single crystal having the basic orientation or more than one crystal grain being shielded by planar defects or linear defect assemblies from the surrounding accompanying low dislocation single crystal region (Z) and the closed defect accumulating region (H) includes crystal defects.

10. A single crystal gallium nitride substrate according to Claim 2, wherein the defects included in the closed defect accumulating region (H) are linear defects or planar defects.

11. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating regions (H) have a diameter ranging from 1 μ m to 200 μ m and discretely disperse on the surfaces.

12. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating regions (H) have a diameter ranging from 5 μ m to 70 μ m and discretely disperse on the surfaces.

13. A single crystal gallium nitride substrate according to Claim 2, wherein shapes of the closed defect accumulating regions (H) are amorphous, circular or polygonal.

14. A single crystal gallium nitride substrate according to Claim 2, wherein the dislocation density is less than $3 \times 10^7 cm^{-2}$ at spots distanced by 30 μ m from the closed defect accumulating region (H) within the accompanying low dislocation single crystal region (Z).

15. A single crystal gallium nitride substrate according to Claim 2, wherein an average of dislocation density in the accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) is less than $5 \times 10^6 cm^{-2}$ and the dislocation density decreases in proportion to a distance from the closed defect accumulating region (H).

16. A single crystal gallium nitride substrate according to Claim 2, wherein the top surface is a (0001) plane.

17. A single crystal gallium nitride substrate according to Claim 2, wherein top surfaces

except the closed defect accumulating regions (H) are (0001) planes and top surfaces of the closed defect accumulating regions (H) are (000-1) planes.

18. A single crystal gallium nitride substrate according to Claim 2, wherein top surfaces except the closed defect accumulating regions (H) are GaN (0001) Ga planes and top surfaces of the closed defect accumulating regions (H) are GaN (000-1) N planes.

19. A single crystal gallium nitride substrate according to Claim 2, wherein top surfaces of the closed defect accumulating regions (H) are slightly lower than top surfaces except the closed defect accumulating regions (H).

20. A single crystal gallium nitride substrate according to Claim 2, wherein almost all the dislocations extend in parallel to a C-plane in the accompanying low dislocation single crystal regions (Z).

21. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating regions (H) extend in a c-axis direction.

22. A single crystal gallium nitride substrate according to Claim 2, wherein the fundamental units (Q) which contain a center closed defect accumulating region (H), an accompanying low dislocation single crystal region (Z) surrounding the closed defect accumulating region (H) and an extra low dislocation single crystal region (Y) enclosing the accompanying low dislocation single crystal region (Z) are aligned periodically and regularly in a symmetric pattern formed in the substrate.

23. A single crystal gallium nitride substrate according to Claim 22, wherein the symmetric pattern is a six-fold rotation symmetry pattern which aligns equivalent equilateral triangles in two dimensionally closest packed hexagonal symmetry and the fundamental units (Q) are disposed at corner points of the equilateral triangles of the pattern.

24. A single crystal gallium nitride substrate according to Claim 23, wherein a direction of a shortest repetition pitch which is equal to a side of the equivalent equilateral triangles of the

hexagonal pattern is either a <1-100> direction or a <11-20> direction.

25. A single crystal gallium nitride substrate according to Claim 22, wherein the symmetric pattern is a four-fold rotation symmetry pattern which aligns equivalent squares crosswise and lengthwise in series and the fundamental units (Q) are disposed at corner points of the squares of the pattern.

26. A single crystal gallium nitride substrate according to Claim 25, wherein a <1-100> direction is either a direction of a shortest repetition pitch which is equal to a side of the equivalent squares of the four-fold rotation summery pattern or a direction of a longest repetition pitch which is equal to an orthogonal line of the equivalent squares of the four-fold rotation summery pattern.

27. A single crystal gallium nitride substrate according to Claim 22, wherein the symmetric pattern is a two-fold rotation symmetry pattern which aligns equivalent rectangles or lozenges crosswise and lengthwise in series and the fundamental units (Q) are disposed at corner points of the rectangles or the lozenges of the pattern.

28. A single crystal gallium nitride substrate according to Claim 27, wherein a direction of a shortest repetition pitch which is equal to a shorter side of the equivalent rectangles or a shorter orthogonal line of the lozenge of the two-fold rotation symmetry pattern is either a <1-100> direction or a <11-20> direction.

29. A single crystal gallium nitride substrate according to Claim 22, wherein a shortest repetition pitch of the closed defect accumulating regions (H) ranges from 50 μ m to 2000 μ m on the surface regularly and periodically provided with the fundamental units (Q).

30. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating regions (H) extend in a c-axis direction and penetrate the substrate crystal.

31. A method of growing a single crystal gallium nitride substrate comprising the steps of:

making pits composed of facets with bottoms on a GaN growing surface;

producing closed defect accumulating regions (H) at the bottoms of the facet pits;

attracting, annihilating and accumulating dislocations in surrounding regions by the closed defect accumulating regions (H); and

reducing the dislocations of the surrounding regions.

32. A method of growing a single crystal gallium nitride substrate comprising the steps of:

implanting seeds on an undersubstrate;

growing a GaN crystal on the undersubstrate in vapor phase on a condition of producing facet pits;

forming pits composed of facets on the growing GaN crystal above the implanted seeds;

making closed defect accumulating regions (H) following bottoms of the facet pits and consisting of cores (S) having converged dislocations and extending perpendicular to the undersubstrate and grain boundaries (K) enclosing the cores (S);

making accompanying low dislocation single crystal regions (Z) surrounding the closed defect accumulating regions (H) under the pit facets;

making extra low dislocation single crystal regions (Y) around the accompanying low dislocation single crystal regions (Z) under a C-plane growing surface outside of the facet pits;

utilizing solely the grain boundaries (K) or both the grain boundaries (K) and the cores (S) enclosed by the grain boundaries (K) as dislocation annihilation/accumulation regions;

gathering dislocations by the facet pits from the accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) to the closed defect accumulating regions (H);

annihilating and accumulating the dislocations in the boundaries (K) or in the

boundaries (K) and the cores (S) of the closed defect accumulating regions (H);

reducing dislocations in the accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y); and

obtaining a low dislocation GaN crystal.

33. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the cores (S) of the closed defect accumulating regions (H) formed at the bottoms of the facets which rise during the growth are polycrystals and the surrounding accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) are single crystals having the same basic orientation.

34. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the surrounding accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) are single crystals having the same basic orientation and the cores (S) of the closed defect accumulating regions (H) are composed of one or more than one crystal grain which has an orientation different from the basic orientation of the surrounding accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y).

35. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the surrounding accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) are single crystals having the same basic orientation and the cores (S) of the closed defect accumulating regions (H) are composed of one or more than one crystal grain which has the same <0001> axis as a <0001> axis of the basic orientation of the surrounding accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y).

36. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the surrounding accompanying low dislocation single crystal regions (Z) and the

extra low dislocation single crystal regions (Y) are single crystals having the same basic orientation and the cores (S) of the closed defect accumulating regions (H) are a single crystal which has a <0001> axis antiparallel to a <0001> axis of the basic orientation of the surrounding accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y).

37. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the surrounding accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) are single crystals having the same basic orientation and the cores (S) of the closed defect accumulating regions (H) are composed of one or more than one crystal grain which has a <0001> axis antiparallel to a <0001> axis of the basic orientation of the surrounding accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y).

38. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the accompanying low dislocation single crystal regions (Z) have the same basic orientation as the extra low dislocation single crystal regions (Y) and the cores (S) of the closed defect accumulating regions (H) are composed of one or more than one crystal grain having an orientation slightly slanting to the basic orientation of the accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y).

39. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the surrounding accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) are single crystals having the same basic orientation, the cores (S) of the closed defect accumulating regions (H) are composed of one or more than one crystal grain and the grain boundaries (K) enclosing the cores (S) are planar defects or linear defect assemblies.

40. A method of growing a single crystal gallium nitride substrate according to Claim 32,

wherein the surrounding accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) are single crystals having the same basic orientation, the cores (S) of the closed defect accumulating regions (H) are single crystals having the basic orientation same as the surrounding accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) and the grain boundaries (K) enclosing the cores (S) are planar defects or linear defect assemblies.

41. A method of growing a single crystal gallium nitride substrate according to Claim 39, wherein the cores (S) of the closed defect accumulating regions (H) contain linear defect assemblies or planar defects.

42. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein an average growing direction in the accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) is a c-axis direction.

43. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the facet pits are hexagonal reverse cones, dodecagonal reverse cones or two stepped hexagonal or dodecagonal reverse cones composed of two sets of facets with different slanting angles.

44. A method of growing a single crystal gallium nitride substrate according to Claim 43, wherein plane indices of the facets building the pits are {kk-2kn} and {k-k0n} (k,n; integers).

45. A method of growing a single crystal gallium nitride substrate according to Claim 44, wherein plane indices of the facets building the pits are {11-22} and {1-101}.

46. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the closed defect accumulating regions (H) following the facet pits grow, maintaining surfaces of plane indices different from the facets building the pits.

47. A method of growing a single crystal gallium nitride substrate according to Claim 46, wherein the closed defect accumulating regions (H) following the facet pits maintain surfaces

of plane indices different from the facets building the pits and of a smaller inclination than the facets building the pits.

48. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the closed defect accumulating regions (H) following the facet pits maintain surfaces of a smaller inclination than the pit facets and an orientation having a <0001> direction antiparallel to a <0001> direction of a basic orientation of the accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y).

49. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the closed defect accumulating regions (H) following the facet pits maintain surfaces of a smaller inclination than the pit facets and an orientation having a <0001> direction antiparallel to a <0001> direction of a basic orientation of the accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) and the surfaces are {11-2-4}, {11-2-5}, {11-2-6}, {1-10-2},{1-10-3} or {1-10-4}.

50. A method of growing a single crystal gallium nitride substrate according to Claim 49, wherein the closed defect accumulating regions (H) following the facet pits maintain an orientation having a <0001> direction antiparallel to a <0001> direction of the basic orientation of the accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) and interfaces which coincide at tops with borders between the pit facets and the smaller inclination surfaces.

51. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the closed defect accumulating regions (H) following the facet pits grow, maintaining discrete dot-converging shapes.

52. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the closed defect accumulating regions (H) following the facet pits grow, maintaining diameters of 1 μm to 200 μm.

53. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the closed defect accumulating regions (H) following the facet pits are amorphous, circular or polygonal in a horizontally sectional shape.

54. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein a plurality of seeds are implanted periodically and regularly in a symmetric pattern on the undersubstrate for aligning the facet pits having a closed defect accumulating region (H) at the bottom periodically and regularly in a symmetric pattern on a surface of a growing crystal during the growth.

55. A method of growing a single crystal gallium nitride substrate according to Claim 54, wherein the symmetric pattern is a six-fold rotation symmetry pattern which aligns equivalent equilateral triangles in hexagonal symmetry and the closed defect accumulating regions (H) are disposed at corner points of the equilateral triangles of the pattern.

56. A method of growing a single crystal gallium nitride substrate according to Claim 54, wherein the symmetric pattern is a four-fold rotation symmetry pattern which aligns equivalent squares in four-fold symmetry and the closed defect accumulating regions (H) are disposed at corner points of the squares of the pattern.

57. A method of growing a single crystal gallium nitride substrate according to Claim 54, wherein the symmetric pattern is a two-fold rotation symmetry pattern which aligns equivalent rectangles in two-fold symmetry and the closed defect accumulating regions (H) are disposed at corner points of the rectangles of the pattern.

58. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein a pitch of the pits which is a center-to-center distance between neighboring pits ranges from 50 μ m to 2000 μ m.

59. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein polycrystalline or amorphous films are disposed upon the undersubstrate as seeds of

the closed defect accumulating regions (H).

60. A method of growing a single crystal gallium nitride substrate according to Claim 59, wherein polycrystalline or amorphous films patterned into rounds, polygons or other definite shapes are disposed upon the undersubstrate as seeds of the closed defect accumulating regions (H).

61. A method of growing a single crystal gallium nitride substrate according to Claim 60, wherein polycrystalline or amorphous films patterned into rounds or polygons of a diameter ranging from 1 μ m to 300 μ m are disposed upon the undersubstrate as seeds of the closed defect accumulating regions (H).

62. A method of growing a single crystal gallium nitride substrate according to Claim 59, wherein silicon dioxide (SiO_2) films, silicon nitride (Si_3N_4) films, platinum (Pt) films or tungsten (W) films are disposed upon the undersubstrate as seeds of the closed defect accumulating regions (H).

63. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein GaN polycrystal particles, GaN single crystal particles or foreign material particles except GaN are disposed upon the undersubstrate as seeds of the closed defect accumulating regions (H).

64. A method of growing a single crystal gallium nitride substrate according to Claim 63, wherein surfaces of a single crystal or a polycrystal of a foreign material are utilized as seeds of the closed defect accumulating regions (H) by making a GaN epi-layer on an undersubstrate of the foreign material, etching partially the GaN epi-layer for exposing parts of the surface of the undersubstrate.

65. A method of growing a single crystal gallium nitride substrate according to Claim 59, wherein surfaces of a polycrystal or an amorphous film of a foreign material are utilized as seeds of the closed defect accumulating regions (H) by optionally making a GaN epi-layer on

an undersubstrate, covering an undersubstrate or the GaN epi-layer piled on the undersubstrate with the polycrystalline or amorphous film of the foreign material, etching partially the foreign material film for exposing parts of the surface of the undersubstrate or the GaN epi-layer and for shaping the rest of the foreign material films into a determined shape and alignment as seeds.

66. A method of growing a single crystal gallium nitride substrate according to Claim 60, wherein dislocations are doubly reduced by disposing patterned polycrystal or amorphous films on an undersubstrate as seeds of making closed defect accumulating regions (H), providing exposed non-seed parts with ELO masks for inducing epitaxial lateral overgrowth, growing a GaN crystal on the undersubstrate having the patterned seeds pattern and the ELO mask on the non-seed parts, reducing dislocations at an early stage of growth by a function of the ELO mask and reducing dislocations at a middle and a final stages of the growth by a function of the closed defect accumulating regions (H) made by the seeds.

67. A method of growing a single crystal gallium nitride substrate according to Claim 60, wherein dislocations are doubly reduced by providing an undersubstrate with an ELO mask, growing a low dislocation GaN film on the undersubstrate with the ELO mask, disposing patterned polycrystal or amorphous films on the GaN film as seeds of making closed defect accumulating regions (H), growing another thick GaN crystal on the undersubstrate having the patterned seeds pattern and the ELO mask on the non-seed parts, reducing dislocations at an early stage of growth by a function of the ELO mask and reducing dislocations at a middle and a final stages of the growth by a function of the closed defect accumulating regions (H) made by the seeds.

68. A method of growing a single crystal gallium nitride substrate according to Claim 32, wherein the undersubstrate is made of GaN, sapphire, silicon carbide (SiC), spinel, gallium arsenide (GaAs) or Si.

69. A method of producing a single crystal gallium nitride substrate comprising the steps of:

implanting seeds on an undersubstrate;

growing a GaN crystal on the undersubstrate in vapor phase on a condition of producing facet pits;

forming pits composed of facets on the growing GaN crystal above the implanted seeds;

making closed defect accumulating regions (H) following bottoms of the facet pits and consisting of cores (S) having converged dislocations and extending perpendicular to the undersubstrate and grain boundaries (K) enclosing the cores (S);

making accompanying low dislocation single crystal regions (Z) surrounding the closed defect accumulating regions (H) under the pit facets;

making extra low dislocation single crystal regions (Y) around the accompanying low dislocation single crystal regions (Z) under a C-plane growing surface outside of the facet pits;

utilizing solely the grain boundaries (K) or both the grain boundaries (K) and the cores (S) enclosed by the grain boundaries (K) as dislocation annihilation/accumulation regions;

gathering dislocations by the facet pits from the accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) to the closed defect accumulating regions (H);

annihilating and accumulating the dislocations in the boundaries (K) or in the boundaries (K) and the cores (S) of the closed defect accumulating regions (H);

reducing dislocations in the accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y);

obtaining a low dislocation GaN crystal;

slicing, grinding, lapping or other mechanical processing the low dislocation GaN crystal for making a uniform GaN substrate without facets and undersubstrate;

polishing the uniform GaN substrate; and

obtaining a flat, smooth GaN substrate.

70. A method of producing a single crystal gallium nitride substrate according to Claim 69, wherein a plurality of GaN wafers are produced by growing a thick low dislocation GaN crystal on the undersubstrate and slicing the thick GaN crystal into a plurality of GaN wafers.

71. A method of producing a single crystal gallium nitride substrate comprising the steps of:

preparing an undersubstrate which is a single crystal gallium nitride substrate including a plurality of fundamental units (Q),

the fundamental unit (Q) containing;

a closed defect accumulating region (H) including a core (S) extending vertical to surfaces of the undersubstrate and containing many accumulated defects and a grain boundary (K) enclosing the core (S),

an accompanying low dislocation single crystal region (Z) surrounding the closed defect accumulating region (H) and being a single crystal of a basic orientation with low dislocation density, and

an extra low dislocation single crystal region (Y) lying outside of the accompanying low dislocation single crystal region (Z) and being a single crystal with the same basic orientation as the accompanying low dislocation single crystal region (Z);

growing a GaN crystal on the GaN undersubstrate in vapor phase on a condition of producing facet pits;

forming pits composed of facets on the growing GaN crystal just above the closed

defect accumulating regions (H) and the accompanying low dislocation single crystal regions (Z) of the GaN undersubstrate;

making closed defect accumulating regions (H) following bottoms of the facet pits and succeeding the closed defect accumulating regions (H) of the GaN undersubstrate,

the closed defect accumulating regions (H) consisting of a core (S) having converged dislocations and extending perpendicular to the undersubstrate and grain boundary (K) enclosing the core (S);

making accompanying low dislocation single crystal regions (Z) surrounding the closed defect accumulating regions (H) under the pit facets and on the accompanying low dislocation single crystal regions (Z) of the GaN undersubstrate;

making extra low dislocation single crystal regions (Y) around the accompanying low dislocation single crystal regions (Z) under a C-plane growing surface outside of the facet pits and on the extra low dislocation single crystal regions (Y) of the GaN undersubstrate;

utilizing solely the grain boundaries (K) or both the grain boundaries (K) and the cores (S) enclosed by the grain boundaries (K) as dislocation annihilation/accumulation regions;

gathering dislocations by the facet pits from the accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) to the closed defect accumulating regions (H);

annihilating and accumulating the dislocations in the boundaries (K) or in the boundaries (K) and the cores (S) of the closed defect accumulating regions (H);

reducing dislocations in the accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y);

obtaining a low dislocation GaN crystal;

slicing, grinding, lapping or other mechanical processing the low dislocation GaN crystal for making a uniform GaN substrate without facets and undersubstrate;

polishing the uniform GaN substrate; and

obtaining a flat, smooth GaN substrate.

72. A method of producing a single crystal gallium nitride substrate according to Claim 71, wherein a plurality of GaN wafers are produced by growing a thick low dislocation GaN crystal on the GaN undersubstrate and slicing the thick GaN crystal into a plurality of GaN wafers.